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**A Field Manual  
of Scientific Protocols  
for the  
Collection of Benthic Macroinvertebrate  
within the  
Upper Columbia Monitoring Strategy**

**2008 Working Version 1.0**

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## TABLE OF CONTENTS

Acknowledgements .....	ii
Table of Contents .....	iii
List of Figures .....	iv
Section 1: Introduction .....	1
Section 2: Sampling Design and Site Selection.....	3
Section 3: Macroinvertebrate Sampling .....	3
Section 3: Data Management .....	6
Section 4: References .....	9
Appendix A: Attribute Table .....	11
Appendix B: Field Gear List .....	12
Appendix C: Protocol Revision Log .....	13

## LIST OF FIGURES

Figure 1. Sample design for benthic macroinvertebrates illustrating kick locations in visually located zones of a single riffle habitat (from Peck et. al., 2001).....	5
Figure 2. Example of a benthos identification tag used in macroinvertebrate collections.....	6

## Section 1: Introduction

### Background and Objectives

Columbia River Basin anadromous salmonids have exhibited precipitous declines over the past 30 years, with several populations now protected under the Endangered Species Act (ESA) (Schaller et al. 1999; McClure et al. 2002). A comprehensive monitoring strategy needs to be implemented to reduce the uncertainties surrounding the declines and the actions required to reverse this trend. Data collected from current and historical monitoring programs are generally not adequate or reliable enough for the purposes of ESA assessments and recovery planning (Tear et al. 1995; Campbell et al. 2002; Morris et al. 2002). In addition, monitoring programs for anadromous salmonids in the Columbia River Basin have typically been initiated to evaluate the effects of specific management actions, such as the demographic effects of hatcheries. As such, data are most appropriately viewed at the scale of the subpopulations and populations for which they were derived. However, the ESA requires assessments of species and their habitat at multiple spatial scales – from specific reaches, to subpopulations, populations, and the ESA management unit of Pacific salmon, the Evolutionary Significant Unit (ESU), which is a distinct population or group of populations that is an important component of the evolutionary legacy of the species.

Current monitoring programs for Pacific salmon did not develop as a cohesive design, thus aggregating existing data from a myriad of independent projects creates challenges in addressing these spatially complex questions. These problems arise because information is often not collected in a randomized fashion (Larsen et al. 2004); sampling techniques and protocols are not standardized across programs; and abundance, distribution, population dynamic, and demographic data for species and their habitat is often not available (Tear et al. 1995; Campbell et al. 2002; McClure et al. 2002). As recovery planning has focused more effort on tributary habitat restoration to mitigate for the mortality resulting from the Federal Columbia River Power System (FCRPS) the limitations of historic and ongoing sampling programs have become increasingly apparent.

The Integrated Status and Effectiveness Monitoring Program (ISEMP – Bonneville Power Administration (BPA) project #2003-0017) was created as a cost effective means of developing protocols and new technologies, novel indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments. These tools are designed to support the development of a region-wide Research, Monitoring and Evaluation (RME) program to assess the status of anadromous salmonid populations, their tributary habitat, and restoration and management actions.

The ISEMP has been initiated in three subbasins: Wenatchee/Entiat, WA, John Day, OR, and Salmon River, ID, with the intent of designing monitoring programs that can efficiently collect information to address multiple management objectives over a broad range of scales. This includes:

- Evaluating the status of anadromous salmonids and their habitat;

- Identifying opportunities to restore habitat function and fish performance, and
- Evaluating the benefits of the actions to the fish populations across the Columbia River Basin.

The multi-scale nature of this goal requires the standardization of protocols and sampling designs that are statistically valid and powerful, properties that are currently inconsistent across the multiple monitoring programs in the region. The Upper Columbia Monitoring Strategy (UCMS, Hillman 2006) is the guiding document under which the ISEMP develops its monitoring and implementation strategies and protocols. The UCMS (Hillman 2006) outlines a monitoring strategy specific to the Upper Columbia Basin that was based on monitoring approaches adopted by the Independent Scientific Advisory Board of the Northwest Planning council (ISAB), Action Agencies/NOAA Fisheries, and the Salmon Recovery Funding Board (SRFB). This approach includes monitoring current conditions (status monitoring), monitoring changes over time at the same sites (trend monitoring), and monitoring the effects of restoration actions on fish populations and habitat conditions (effectiveness monitoring).

Although the UCMS (Hillman 2006) identifies the project area as the Wenatchee, Entiat, Methow, and the Okanogan River subbasins, this and other ISEMP protocols have been implemented as pilot projects in the Wenatchee and Entiat River subbasins. Monitoring in the Okanogan River subbasin is conducted by the Colville Tribe under the Okanogan Basin Monitoring and Effectiveness Plan (OBMEP) using protocols similar to, but differing in some areas, ISEMP protocols. A comprehensive and coordinated monitoring in the Methow River is under development.

The ISEMP program has taken an experimental approach to the development of scientific monitoring protocols. Hence, this document is best viewed as a working draft that is subject to change as the ISEMP program adds, subtracts, or modifies portions of these methods. Changes to methods are adopted at the beginning of the field season and adhered to until the next year's manual is completed. However, because another purpose for this document is to prepare for the development of a final field manual when ISEMP is ready to propose standardized monitoring program elements, this manual also serves as a draft template for future ISEMP field manuals. This macroinvertebrate collection protocol is a component of the overall ISEMP, and while it stands alone as an important contribution to the management of anadromous salmonids and their habitat, it also plays a key role within ISEMP as it is built on a standardized format following Oakley et al. (2003) that all of the ISEMP protocols adhere to.

This document was created as an internal guide for field practitioners working within BPA's ISEMP. This draft document has been updated and revised for the 2008 field season. The methods described by this protocol are intended to provide for the standardized collection of macroinvertebrates in the Entiat and Wenatchee subbasins as recommended by the UCMS (Hillman 2006) and meet the criteria established by PNAMP (2006). This manual is designed for quick reference in the field, and is arranged in the order that crews would be generally expected to follow. Detailed descriptions of how to measure indicators have been included to reduce observer variation. It is appropriate to use this manual when performing status/trend monitoring or effectiveness monitoring in the Upper Columbia Basin, although study design

requirements for specific effectiveness monitoring projects may require that aspects of these protocols be modified.

## **Section 2: Sampling Design and Site Selection**

This protocol is designed to standardize benthic macroinvertebrate collection methods in the Upper Columbia Basin. The UCMS (Hillman 2006) serves as the primary reference for sampling designs at the basin and subbasin scale. It may be appropriate to modify these sampling designs in order to address specific questions within any particular subbasin of the Upper Columbia Basin. Benthic macroinvertebrates surveys are conducted as a part of status and trend monitoring where the intention is to characterize macroinvertebrate assemblages and trends at the watershed level using randomly selected sites. Benthic macroinvertebrate surveys are also conducted as a part of effectiveness monitoring, where a Before-After-Impact-Control (BACI) sample design characterizes changes in stream conditions in response to localized restoration activities. Integrating status and trend monitoring with effectiveness monitoring allows comparison of trends at the watershed scale to trends seen at the reach scale, and helps establish the degree to which causal inferences can be made to explain trends resulting from local restoration actions. Under the ISEMP study design, macroinvertebrates are collected at the same X-sites where habitat surveys are carried out. For a detailed description of how to select a site see “A Field Manual of Scientific Protocols for Selecting Sampling Sites used in the Integrated Status and Effectiveness Monitoring Program” (Moberg and Ward 2008), and for detailed description on how to lay out a site see “A Field Manual of Scientific Protocols for Habitat Surveys within the Upper Columbia Monitoring Strategy” (Moberg 2008).

## **Section 3: Macroinvertebrate Sampling**

### **References:**

Peck et al. (2001), PNAMP (2006), Klemm et al. (2001), Gibson et al. (1996)

### **Equipment:**

D frame kick net with 500-micron screens, clean container, ethanol, waterproof labels, stopwatch, random number generator, and a bristle scrubber.

### **Concept:**

Benthic macroinvertebrate composition is an important indicator of aquatic invertebrates in streams. Benthic macroinvertebrate assemblages in streams reflect overall biological integrity of the benthic community and because benthic communities respond to a wide array of stressors in different ways, it is often possible to determine the type of stress that affects a macroinvertebrate community. Macroinvertebrate assemblages integrate stressor effects over the course of the year, and their seasonal cycles of abundance and taxa composition are fairly predictable within the limits of interannual variability (Gibson et al. 1996). Sampling and comparing data from the same season (or index period) as the previous year's sampling provides

some correction and minimization of annual variability. The index period for the ISEMP 2008 invertebrate collection is from July 1<sup>st</sup> – September 30<sup>th</sup>.

**Procedure:**

Macroinvertebrate sampling procedures follow the 8-ft<sup>2</sup> “targeted riffle” protocol for EMAP outlined by Klemm and others (2001), and are similar to the PNAMP protocol (PNAMP 2006). Aquatic macroinvertebrates are sampled after the site has been laid out following procedures in “A Field Manual of Scientific Protocols for Habitat Sampling within the Upper Columbia Monitoring Strategy” (Moberg 2008). Finish the site lay out before macroinvertebrate sampling begins to avoid disturbing the streambed. Starting at transect A, and proceeding upstream, conduct the macroinvertebrate sampling using a “targeted riffle” sample approach. The site composite sample comes from eight separate 1-ft<sup>2</sup> kick samples collected randomly from as many as eight separate riffles spread across the reach.

**Step 1:** Examine the reach for riffle habitat. The goal is to collect the composite sample by distributing eight samples throughout the length of site (from transects A to K, Figure 1). If there are eight or more separate riffles then sample eight riffles throughout the site. If less than eight riffles are present in the reach, the crew should sample from four riffle habitats throughout the reach, collecting two samples from each riffle, being careful not to sample more than once from a single zone in a riffle (Figure 1). If less than four riffles are present then collect eight samples throughout the site where riffle habitat is present. The sample location in each riffle is randomly selected from one out of nine possible zones in the riffle. Begin at the first riffle upstream from transect A, divide the riffle visually into nine zones (three zones extending upstream by three zones extending across the riffle). Exclude “margin” habitats by constraining the potential sampling area. Margin habitats are edges along the channel margins or upstream or downstream edges of the riffle. If the site does not have enough riffle area to collect all eight samples then collect as many as possible, and clearly note on the labels that an abbreviated composite sample was taken. Note the total area sampled and how many kick samples were taken.

**Step 2:** Place the kick net in the center of the visually located zone selected in Step 1. Ensure that the net is placed firmly on the surface so that there is no open space below the net. Have the recorder hold and secure the net in place, or if sampling alone, secure the net with knees or feet. Remove and vigorously scrub the entire surface of any easily moveable rocks larger than a golf ball so that all the macroinvertebrates flow into the net. Visually check the rocks to ensure that all the macroinvertebrates are removed. Once the rocks are clean, place them outside the sampling area. Next, kick a 1- ft<sup>2</sup> area upstream of the net for 30 seconds, kicking toward the net. Check there is sufficient water flow through the net.

**Step 3:** Examine the contents of the net. Remove and scrub any rocks larger than golf balls that have entered the net. Continue sampling upstream until 8 square feet of riffle habitat are sampled across the reach. Once the net has picked up enough debris to impede further collection, empty the contents into a container and proceed upstream.

**Step 4:** Combine the eight kick samples into a single composite sample, and preserve in 95% ethanol (final concentration not less than 70% ethanol). When emptying net into composite bucket make sure to inspect the sides of net for smaller specimens and, if needed, use tweezers to remove them from net.

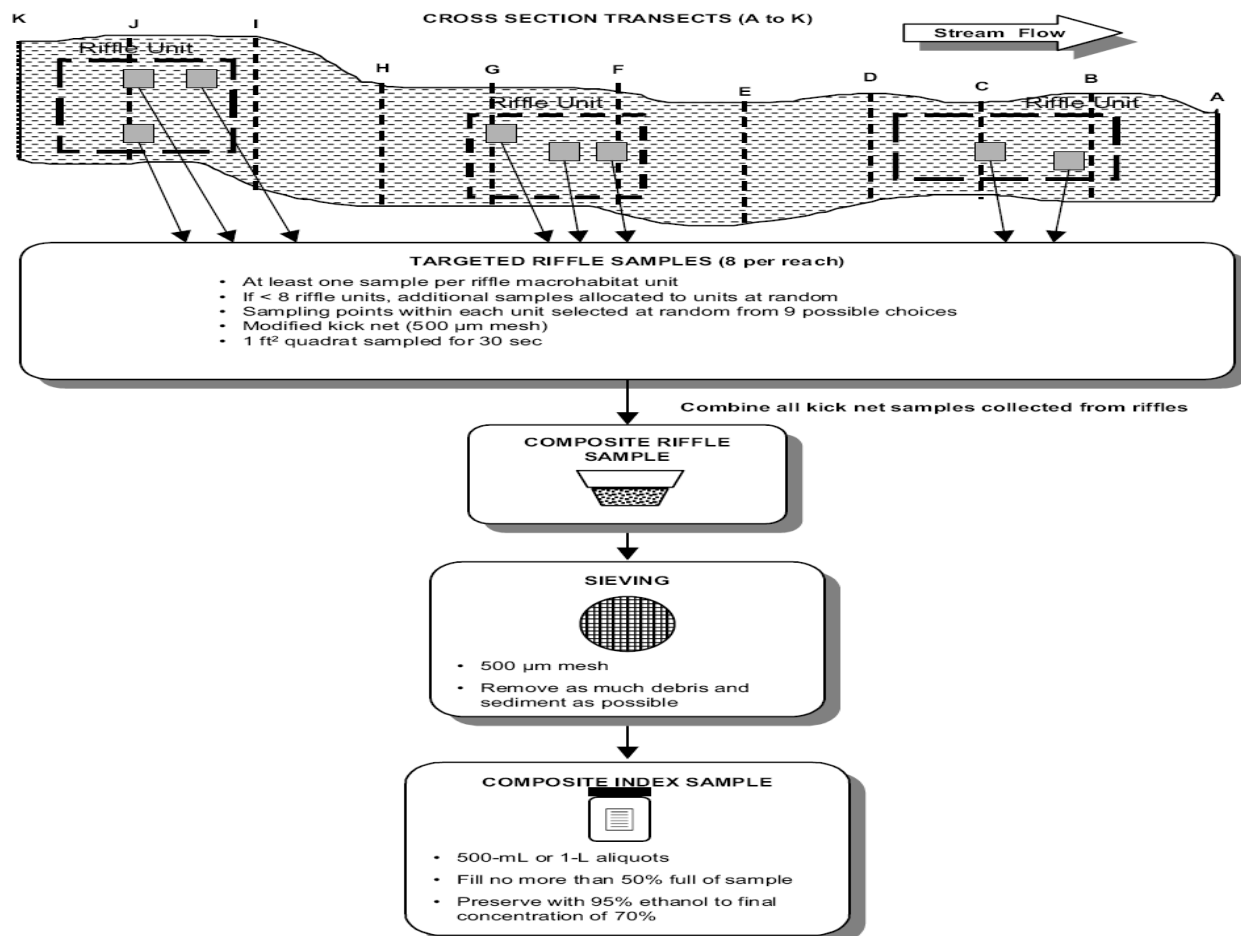


Figure 1. Sample design for benthic macroinvertebrates illustrating kick locations in visually located zones of a single riffle habitat (from Peck et. al., 2001).

**Step 5:** Complete a sample ID tag and place in the sample container (Table 2). Sample ID tags are write-in-the-rain tags that include the Data Collection Event (DCE), the project name, the stream name, the collector, and the total area of the sample. Close the container and write the DCE, the project name, the stream name, and the collector on the lid. The DCE is a combination of the site name (including the GRTS site list name if applicable), date sampled, and time sampled (using 24 hour time).

**Step 6:** Maintain a record of all collected samples in a chain of custody file. Chain of custody file should contain the DCE, stream name, and number of jars per sample, special notes, and the date the samples are delivered to the lab.

**Step 7:** In the laboratory, at least 500 benthic macroinvertebrates should be sorted out of each composite sample in a random systematic fashion. The macroinvertebrates will be identified to the lowest practical level, (typically genus) as found on the “Standard Taxonomic list for the Northwest,” recommended by the Pacific Northwest Taxonomic Workgroup.

**BENTHOS IDENTIFICATION**

DCE: WC503432-040619-20060831-1330

Project: ISEMP

Stream: Chiwawa River

Collector(s): J. Doe

Sample size: 8 sq. ft.

Figure 2. Example of a benthos identification tag used in macroinvertebrate collections.

***Personnel requirements and training***

Each monitoring agency is responsible for training the personnel who will be carrying out the macroinvertebrate surveys, including water safety courses.

**Section 3: Data Management****Data management framework**

The ISEMP Data Management effort is designed to develop standardized tools and procedures for the organization, reduction, and communication of monitoring data and methods within ISEMP pilot basins located in the Wenatchee and Entiat subbasins, WA, John Day, OR, and Salmon River, ID. Beginning in 2004, a pilot project has been under development aimed at integrating four primary data management tools: Automated Template Modules (ATMs), the Status Trend and Effectiveness Monitoring Databank (STEM databank), Protocol Editor (PE), and the Aquatic Resources Schema (ARS). The STEM Databank is the central data repository for the ISEMP project. It was developed by the Scientific Data Management Team at NOAA-Fisheries to: (1) accommodate large volumes of data from multiple agencies and projects; (2) summarize data based on how, when, and where data were collected; (3) support a range of analytical methods; (4) develop a web-based data query and retrieval system, and (5) adapt to changing requirements. This fully-normalized database structure allows the incorporation of new attributes or removal of obsolete attributes without modification of the database structure. Data can be summarized in a variety of formats to meet most reporting and analytical requirements.

Successful data management systems require a user interface that is intuitive to the user and that increase the efficiency of the user’s workflow. The ATMs are a collection of forms that allow users to enter and view data in a format that is familiar to biologists. Each ATM has forms

for entering new data, reviewing existing data, and updating existing data. Additionally, each ATM has a switchboard to help guide the user to the correct forms.

The general layout of the forms includes a header section to display information about the data collection event and a series of tabs that display detailed observational data. The header section describes the general characteristics about when, where, and how the data was collected or observed. The header section always includes the site, the start date and time, and the protocol. Additionally, the header section may include general characteristics about the sampling reach or unit, environmental conditions, weather conditions, water temperature and visibility, presence of fish, and protocol deviations. A series of tabs below the header section display detailed observations that occurred during the data collection event in spreadsheet format. Tabs vary between the different ATMs, but typically include a tab for crew and for equipment.

Data entry forms perform the critical function of validating data at the time of data entry. For categorical attributes, users are only allowed to select from acceptable categories as defined by the protocol. Similarly, values entered for continuous attributes are checked to ensure values are within the expected range. Data entry forms are “protocol aware”. The database includes tabular data that specifies details about the protocol. All categorical fields on data entry forms have pull-down lists that limit the values a user can enter for the field. The pull-down lists reference the protocol documentation tables and only display values that are defined for the active protocol. Similarly, for continuous values, the forms check the expected range as defined in the protocol and warn the user if the entered value falls outside of the expected range. Users can choose to modify the value or accept the value as it was entered. The use of “soft” bounds on continuous values is an effective validation strategy for ecological data, where data often follows a normal distribution with long tails as opposite to a discrete distribution common to financial data.

The ATMs also apply an innovative approach to solving the species code issue. Short species code abbreviations are often used by field biologist to speed data recording in the field. However, every agency or program uses a uniquely defined set of species codes that are appropriate for their geographic location and data gathering requirements. When data containing these idiosyncratic species codes are submitted to regional data warehouses, the codes often become meaningless or indecipherable. A simple solution requires field biologist to define their species codes as tabular data in the database. The definition for each species code includes the scientific name, life stage, age class, run, and origin. Scientific name is the only required field and the name must be recognized by a taxonomic authority. Forms in the ATMs allow users to select from the list of defined species codes. When a species code is selected, the forms store all five fields in the data table. This ensures that the definition of the code is never separated from the raw data and facilitates efficient analysis by allowing users to select or aggregate on any one of the five fields that make up a species code.

Protocol Editor is a data dictionary, user-friendly tool for describing the list of all attributes collected by a given protocol that includes a description of the data type, units of measure, number of characters or digits, number of decimal places, and list of acceptable values for all attributes collected by a protocol. Protocol Editor allows the ATM to be calibrated to a

given protocol and allows the ATM to ensure consistency between the protocol and the data entered for that protocol. Protocol Editor follows the same rules established by Protocol Manager (a protocol documenting tool being developed by U.S. Bureau of Reclamation). A protocol is defined as a collection of methods, where each method consists of the list of attributes to be recorded by the data collector. The name of attributes is restricted to attributes defined by the ARS; however, users are allowed to create an alias name for the attributes. Metadata entered into Protocol Editor can easily be exported in a tabular format for importing into Protocol Manager.

The ARS is the collection of database tables that store data entered into the ATM forms. The ARS was developed to support agencies within the Columbia River Basin manage, document, and analyze aquatic resources data. The ARS aims to define a standardized data structure for storing and processing water quality, fish abundance, and stream habitat data. The ARS is robust against variations between data collection protocols, supports procedures for increasing data integrity at the time of data entry, and supports proper analysis and summarization of aquatic resources data.

### **Data handling**

Benthic invertebrate data is provided by the analyzing lab to the Upper Columbia Data Steward for uploading into the STEM Databank. QAQC is completed by the lab before it is uploaded. Site and sample information for all the invertebrate samples taken in a year are contained in a chain-of-custody file for that year. The chain-of-custody file is transferred with the samples to the analyzing lab and used to assure all samples were delivered and complete. Any errors associated with the samples are handled within this file.

### **Data Analysis**

*This section is under development by the ISEMP data analysis team and will be updated in the next round of revisions to the working draft.*

### **Data reporting**

The ISEMP coordinator is responsible for preparing an annual report that will follow the outline below covering the macroinvertebrate collection period:

1. Brief abstract (limit 600 words).
2. Standard introduction provided by ISEMP plus brief description of specific project(s) covered in report.
3. Concise description of project area/map.
4. Description of methods and materials used to perform tasks.
5. Summary of results and brief discussion of results by task (problems encountered, suggestions for future work).

6. If necessary, supplemental electronic copies of summarized field data in spreadsheet or GIS format.

7. Data obtained from the analyzing lab will be uploaded to NOAA Oracle.

The annual report shall be submitted to the BPA Project Manager/COTR and ISEMP coordinator. Guidelines for preparing the report can be found at [http://www.efw.bpa.gov/Integrated\\_Fish\\_and\\_Wildlife\\_Program/ReportingGuidelines.pdf](http://www.efw.bpa.gov/Integrated_Fish_and_Wildlife_Program/ReportingGuidelines.pdf). The Upper Columbia Data Steward is responsible for generating an annual report to the Watershed Action Teams, Project Sponsors and monitoring agencies that will include a summary of the macroinvertebrate data.

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*[Although this draft document states that it should not be cited or quoted, some of the material in the report is an important improvement to Lazorchak et al. (1998). By not citing the document, it may give the appearance that we improved some of the methods outlined in the Lazorchak et al. report. To avoid this, we feel it necessary to offer credit where credit is due.]*
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## **Appendix A: Attribute Table**

*This section is under development by the ISEMP Data Management Team and will be included in the next working version.*

## **Appendix B: Field Gear List**

- ☐ D frame kick net with 500-micron screens
- ☐ Clean containers
- ☐ Ethanol
- ☐ Waterproof labels
- ☐ Stopwatch
- ☐ Random number generator
- ☐ Bristle scrubber

## **Appendix C: Protocol Revision Log**

As new information becomes available and macroinvertebrate monitoring efforts are refined, the protocol will be revised. Effectively tracking past and current protocol versions are important for data summaries and analyses that utilize data collected under different protocol versions. Protocol Editor will house previous and current protocol versions and the dates of their implementation. Reviews will be performed for all proposed changes to the protocol and the Upper Columbia Data Steward notified so the version number can be recorded in the project metadata and any necessary changes can be made to database structure (Peitz et al. 2002). Consistent with the recommendations of Oakley et al. (2003) this protocol includes a log of its revision history. The revision history log (adapted from Peitz et al. 2002) will track the protocol version number, revision dates, changes made, the rationale for the changes, and the author that made the changes. Revisions or additions to existing methods will be reviewed by ISEMP staff prior to implementation. Major revisions such as a complete change in methods will necessitate a broader review by outside technical experts. When the protocol warrants significant changes the protocol version and date on the title page should be updated to reflect the new version. Version numbers should increase incrementally by hundredths (e.g., Version 1.01, 1.02 etc.) for minor changes and by the next whole number (e.g., version 2.0, 3.0 etc.) for major changes (Peitz et al. 2002).

**Protocol Revision History Log**

Previous Version #	New Version #	Revision Date	Author	Changes made	Reason

(adapted from Peitz et al. 2002)